

APPENDIX E

SIGNIFICANCE OF TESTS

Knock Values

Knock values indicate whether a fuel will burn uniformly and evenly in a cylinder without preignition or detonation. The knock values are expressed as octane numbers for automotive-type engine gasolines and as a combination of octane and performance numbers for aviation gasolines. These values are determined by comparing the knocking tendency of fuel samples to those of standard test fuels of known knock values in a standard test engine. Fuel of inadequate knock value will reduce the power output of all types of engines. If used for more than brief periods, it can cause overheating of the engine, burned or melted pistons and cylinders, and lubrication failure.

Cetane Number

The ignition quality of a diesel fuel, which is based on a scale resembling that of octane number, is expressed in terms of cetane number. This number indicates the length of time (ignition lag) between injection of the fuel and combustion. The cetane number requirement varies with the type of diesel engine. Large, slow-speed units in stationary installations do not require diesel fuel with cetane ratings above 40. Smaller, high-speed engines (1,000 rpm or more) require fuel of high cetane number. In the absence of test engines, cetane numbers are approximated from the calculated cetane index (ASTM D975).

Color

Color serves primarily as an aid for identifying fuels such as aviation and automotive gasolines which have characteristic colors. Failure of a fuel to meet its color requirement may indicate the possibility of contamination or deterioration. Darkening of the color of jet fuel may indicate the formation of insoluble gums.

Corrosion

Quantitative and qualitative tests for corrosion indicate whether products are free of corrosive tendencies. The quantitative test determines total sulfur content, which is important particularly when a product is to be burned in lamps, heating appliances, or engines. The qualitative test, usually made with bright copper strips, shows if fuel will corrode the metal parts of fuel systems.

Existent Gum

As the name implies, gum is the sticky, tacky, varnish-like material that is objectionable in fuel systems. Existent gum is the nonvolatile residue present in gasoline or jet fuels after they have been tested. The results indicate the quantity of gum deposit that may occur if the product is used immediately but do not indicate the possibility of gum formation when the product is stored. When present in excess, gum clogs fuel lines, filter and pump screens, and carburetor jets; causes manifold deposits and sticky intake valves; and reduces the knock value of gasoline.

Potential Gum

Potential gum (sometimes called oxidation stability) is determined by a test that indicates the presence of gum forming materials and the relative tendency of gasolines and jet fuels to form gums after a specified period of accelerated aging. This value is used as an indication of the tendency of fuels to form gum during extended storage. Retention of the original properties of a fuel after prolonged storage is known as the stability of the fuel. When added to fuels, chemical inhibitors retard gum formation but will not reduce gum that has already been formed. The effects of potential gum are similar to those described for existent gum.

- For automotive gasolines, the potential

gum may be expressed as the “induction period” (sometimes called the breakdown time). This is a measure of the time (in minutes) elapsed during the accelerated test until the fuel absorbs oxygen rapidly.

- For aviation gasoline and jet fuel, the potential gum may be expressed as the “potential or accelerated gum.” This is the gum plus lead deposits (from leaded fuels) measured at the end of a specified accelerated aging (oxidation) period.

Flashpoint

The flashpoint is the lowest temperature at which vapors rising from a petroleum product of a flame under specified conditions will ignite momentarily (i.e. flash) on application. The flashpoint of a petroleum product indicates the fire hazard in handling and storing it. It applies to fuel oils, diesel fuels, JP5, kerosene, and solvents. (It is not used for JP4.) The flashpoint test also indicates the contamination of a product. For example, the presence of very small quantities of gasoline will make the flashpoint of a diesel fuel considerably lower than the minimum safe operating level. The flashpoint of a new lubricating oil is used primarily for identification and classification. The flashpoint of the oil must be above the operating temperature of the engine in which it is to be used.

Cloud and Pour Points

- The cloud point is the temperature at which wax crystals (normally held in solution or water) in an oil separate, causing the oil to appear cloudy or hazy. In wick-fed systems, the wax crystals may clog the wick. Both wax crystals and water may block filter passages in fuel systems.

- The pour point of an oil indicates its behavior at low temperatures. The fact that an oil has a specific pour point is no guarantee that it can be handled or is a satisfactory lubricant at that temperature.

Distillation

This process is used to measure the volatility of a petroleum product. The lower boiling

fractions of gasoline indicate the starting ability of a gasoline engine at a given temperature and the engine’s ability to warm up quickly. An excessive amount of highly volatile constituents in gasoline may cause vapor lock. Conversely, a gasoline with an excessive amount of “heavy ends” may not completely burn in the combustion chamber. This may cause damage through excessive dilution of crankcase oil. Specifications designate minimum and maximum percentages of fractions to be evaporated at specified temperatures, as well as initial and final boiling points. A gasoline with a high end point and a high percentage of residue may be contaminated with fuel oil or other oils. A fuel oil with a considerably lower initial boiling point or flashpoint than normal may be contaminated with gasoline.

Viscosity

Viscosity is the measure of a liquid’s resistance to flow. Specified minimum and maximum flow rates are required for all fuel oils and lubricating oils. A fuel oil’s viscosity shows how the oil will flow to the burners, the extent to which it will be atomized, and the temperature at which the oil must be maintained to atomize properly.

Reid Vapor Pressure

The vapor pressure of a fuel, which indicates the tendency of the fuel to vaporize, is determined by the Reid vapor pressure test. For any given gasoline, vapor pressure increases with temperature. Gasolines must have a certain vapor pressure to insure adequate starting and accelerating qualities. Too high a vapor pressure for the particular operating condition may cause vapor lock, which prevents the fuel from reaching the engine.

Carbon Residue

The carbon residue test indicates the carbonizing properties of lubricating or burner oil. However, carbon residue from lubricating oils is not directly related to carbon formation in an engine. This test gives an indication of the type of carbon formation (loose and flaky

or hard and flinty). It is used primarily as an identity and control test in conjunction with other specification tests. After distilling off 90 percent diesel fuel, the carbon residue in the remaining 10 percent must be low enough to avoid large carbon deposits. Coking in the injector of a diesel engine will seriously affect the fuel spray. High carbon residue fuels should be carefully checked for carbon formation.

Bottom Sediment and Water

Petroleum products may gain sediment and water during storage and handling. This can adversely affect the performance of equipment in which the products are used.

- *Aviation Fuels.* Contamination by bottom sediment and water (BS&W) can often be detected visually because such contamination is not miscible with the fuel. As a general rule, aviation fuel must be clean and bright and contain no free water. The terms clean and bright do not refer to the natural color of the fuel; the various grades of aviation gasoline have dyes added. Jet fuels are not dyed and may be any color from water-white to amber. Clean means the absence of any cloud, emulsion, readily visible sediment, or entrained water. Bright refers to the shiny appearance of clean, dry fuels. A cloud, haze, specks of sediment, or entrained water indicate that the fuel is unsuitable, pointing to a breakdown in fuel-handling equipment. Steps should be taken to find the trouble source and correct it immediately. The following information is also applicable to automotive fuels.

- *Cloudy or hazy fuel.* Usually a cloud indicates water, but it may also indicate excessive amounts of fine sediment or finely dispersed stabilized emulsion. Fuel containing a cloud from either cause is not acceptable. When clean and bright fuel cools, a light cloud may form indicating that dissolved water has precipitated out. This precipitation cloud represents a very slight amount of fresh water. However, even a slight amount is not desirable in aviation fuel. Fuel that shows a precipitation cloud may not be clean and should not be accepted.

The filter/separator elements should be replaced and water and emulsion should be removed from the source tank. A properly operating filter/separator can be used to remove the precipitation cloud by recirculation or by draining the fuel upstream.

- *Sediment in fuel.* Specks or granules of sediment indicate particles in the visible size range, i.e., greater than 40 microns. An appreciable number of such particles in a sample indicate a failure of the filter/separator, contamination downstream of the filter/separator, or a dirty sample container. Even with the most efficient filter/separators and careful fuel handling, an occasional visible particle will be noted. These stray particles are due to particle migration through the filter media and may represent no particular problem to the engine or fuel control. The sediment ordinarily noted is an extremely fine powder, rouge, or silt. In a clean sample of fuel, sediment should not be visible. If sediment continues to be noted, appropriate surveillance tests and corrective measures must be applied to the fuel handling system.

- *Diesel Fuels and Burner Oils.* In order to avoid fuel pump and injector difficulties, diesel fuels must be clean and should not contain more than a trace of foreign substances. Excessive sediment and rust in burner oils will plug the burner tip, and the fuel will not atomize properly. Water can cause ragged operation and may corrode the fuel handling system. The types of equipment and burner oils will determine the amount of sediment permissible in the fuel.

- *Lubricating Oils.* Care should be taken to avoid contaminating lubricating oils with water. Water will hasten the decomposition of many oils, washout additives, cause the oil to emulsify, and lead to engine failure. In used lubricating oils, sediment and water may have been caused by poor maintenance, failure of screens, or by condensation of combustion products.

Ash

The ash in oil is determined by burning off

the organic matter and weighing the remaining inorganic matter, Straight mineral oils usually contain only a trace of ash. Oils containing metallic salts as additives will have larger amounts of ash. Increased ash indicates contamination with inorganic matter such as sand, dust, and rust. Increased ash in straight mineral oils may indicate contamination with additive-type oils. The ash in diesel fuels must be very low because any abrasive substances may damage the internal metal surfaces of engines and injectors or plug injection nozzles and may also form deposits on working surfaces. Residual fuel oils should also have low amounts of ash to prevent corrosion or embrittlement of fire boxes and boiler tubes.

Foam Stability

All oils will foam to some extent when agitated. The foam that is formed in oils that contain additives is often very stable. Instead of breaking up quickly, the foam tends to build up, and oil is lost through the breather outlets and other openings in the engine crankcase. Therefore, additive-type motor oils are frequently treated with antifoam agents to eliminate potential foaming problems. The foam test requires agitating the oil until a large amount of foam is formed and then noting the time required for the foam to break up and disappear.

Gravity

Accurate determination of the gravity of petroleum products is necessary for converting measured volumes to volumes at the standard temperature of 60° F. Gravity is a factor governing the quality of crude oils. However, the gravity of a petroleum product is an uncertain indication of its quality. Combined with other properties, gravity can be used to give approximate hydrocarbon composition and heat of combustion. The gravity scale most used in the United States is the API (American Petroleum Institute) gravity. A change of gravity may indicate a change of composition caused by mixing of grades of products.

Water Reaction

This test determines the presence of water-miscible components in aviation gasolines and turbine fuels, and the effect of these components on the fuel-water interface.

Fuel System Icing Inhibitor (FSII) Test

This is a quantitative test used to determine the concentration of fuel system icing inhibitor in jet fuel. The FSII additive (ethylene glycol monomethyl ether-glycerol) prevents ice formation in aircraft fuel systems. Testing is performed by several methods; i.e., colormetric, seiscor refractometer, freezing point, and titration. The potassium bichromate-sulfuric acid titrimetric procedure is the method preferred by the Air Force.

Water Separometer Index Modified (WSIM)

The WSIM test measures the ease with which a fuel releases dispersed or emulsified water. Fuels having a low WSIM rating will prevent filter/separators from functioning properly.

Particulate Contaminant

Excessive sediment (particulate contaminant) will clog fuel lines and internal fuel filters on aircraft. Sediment may also cause wear on metal parts and, when burned, may form deposits causing premature engine failure. The two tests for particulate contaminant in aviation turbine fuels are the Millipore test and the color comparison standards test (commonly called the Air Force method).

- The Millipore test, ASTM D-2276, is used primarily to test aviation turbine fuels for particulate contaminant. However, specifications for aviation gasoline and some diesel fuels also require the Millipore test.

- The color comparison standards test as outlined in USAF TO 42 B-1-1 is authorized for use by the Army. The procedures are outlined in Appendix A3 of ASTM D-2276. The color standards are available under NSN 6640-00-326-7684. The color comparison standards may be used in addition to laboratory

testing, but are not authorized as a substitute for laboratory testing. If the fuel passes the color test, it may be used while awaiting laboratory test results. If the fuel fails the color test, it must not be used and a sample must still be sent to the laboratory.

Undissolved Water

Undissolved (free) water in aviation fuels can encourage the growth of microorganisms and subsequent corrosion in aircraft tanks and can also lead to icing of filters in the fuel system. Free water is controlled in ground fueling equipment by filter/separators. The Aqua-Glo test is a quick and accurate way to determine the amount of free water in liquid

petroleum products. The procedure is found in ASTM D-3240. Water in fuel can cause the following severe problems:

- Corrosion of tanks, equipment, and lines due to the formation of hydrogen sulfide, an extremely corrosive compound.
- Removal of FSII from aviation turbine fuels.
- Clogging of fuel lines and filters, particularly at high altitudes.
- Support of microbiological growth, sometimes found in the water and fuel interface in jet fuel tanks.